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MERCURY USE, RELEASE AND REDUCTION INITIATIVES AT NOVA SCOTIA HOSPITALS

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Environmental Protection Branch
Atlantic Region
Environment Canada
16th Floor, Queen Square
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B2Y 2N6

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MERCURY USE, RELEASE AND REDUCTION INITIATIVES AT NOVA SCOTIA HOSPITALS

L.A. Rutherford[1], *L. Rankin*[2], *and M.R. Bernier*[3]

[1]Environment Canada, Environmental Protection Branch, Dartmouth, NS

[2]Nova Scotia Department of Environment and Labour, Halifax, NS

[3]Environment Canada, Environmental Conservation Branch, Moncton, NB

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ABSTRACT

A study was conducted to determine mercury use, release and reduction initiatives at 17 hospitals in Nova Scotia. On two occasions over a period of five months, a 24 hour composite sample of the final wastewater from each facility was collected and analyzed for total mercury concentrations. In addition, a questionnaire was developed and used to determine mercury use patterns and reduction initiatives at those facilities. Total mercury concentrations in hospital wastewaters ranged from 0.0064 to 0.26 µg/L with a mean concentration of 0.10 µg/L. Mean mercury concentrations from hospitals were 3.3 times higher than mean concentrations from reference stations. Sixteen of the 17 hospitals surveyed had mercury concentrations within the range of concentrations that have been shown to cause impaired reproduction in sensitive aquatic organisms. Estimated annual mercury loadings ranged from 3.2 to 138.6 g/yr with an average discharge of 65.3 g/yr. While some hospitals had already made efforts to reduce mercury use and implement environmentally responsible mercury management practices, many hospitals had not made such efforts. A lack of information on identifying less obvious sources of mercury in equipment, products and laboratory chemicals and on sample policies/practices for mercury handling and management were cited as reasons why mercury reduction programmes were not implemented at many hospitals. However, even where efforts had been made to reduce or eliminate mercury use, mercury concentrations in hospital wastewaters remained higher than background concentrations, raising doubts about the effectiveness of those measures or whether additional sources of mercury had not been identified.

RÉSUMÉ

Une étude avait pour but de déterminer l'utilisation du mercure, son rejet et les mesures de réduction dans 17 hôpitaux de la Nouvelle-Écosse. À deux occasions sur une période de cinq mois, un échantillon composite de 24 heures des eaux usées finales de chaque établissement a été prélevé et a été soumis à un dosage du mercure total. En outre, un questionnaire a été utilisé pour déterminer les profils d'utilisation du mercure et les mesures de réduction dans ces établissements. Les concentrations de mercure total dans les eaux usées des hôpitaux variaient entre 0,0064 et 0,26 µg/L, la concentration moyenne étant de 0,10 µg/L. Les concentrations moyennes de mercure dans les hôpitaux étaient 3,3 fois plus élevées que dans les stations de référence. Seize des 17 hôpitaux étudiés présentaient des concentrations de mercure dans la gamme de celles qui affectent la reproduction des organismes aquatiques sensibles. Les charges de mercure annuelles estimées variaient de 3,2 à 138,6 g par année, avec des rejets moyens de 65,3 g par année. Certains hôpitaux ont déjà fait des efforts pour réduire leur utilisation de mercure et ont mis en œuvre des pratiques de gestion du mercure respectant l'environnement, mais de nombreux hôpitaux n'ont rien fait de tel. Beaucoup d'hôpitaux ont donné comme raisons pour ne pas avoir mis en œuvre de programmes de réduction du mercure l'incapacité de déterminer les sources moins évidentes de mercure dans l'équipement, les produits et les composés chimiques utilisés dans les laboratoires et l'absence d'information sur les politiques ou pratiques d'utilisation et de gestion du mercure. Toutefois, même là où des efforts ont été déployés pour réduire ou cesser l'utilisation de mercure, les concentrations de mercure dans les eaux usées de l'hôpital sont demeurées plus élevées que les concentrations de fond. Il y a donc lieu de s'interroger sur l'efficacité des mesures prises ou sur la présence de sources de mercure non détectées.

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1.0 Introduction

Mercury is a persistent, toxic substance that bioaccumulates in aquatic food chains. High concentrations of mercury in fish pose serious health risks to humans and wildlife that consume them. In Nova Scotia, mercury has been found to have reproductive effects on fish-eating water birds (Nocera and Taylor 1998) and has contaminated fish to the point that consumption advisories have been issued for some freshwater sport fish (NS Dept. of Agriculture and Fisheries 2002).

Mercury, a naturally occurring element, occurs in the environment in both organic and inorganic forms. Mercury circulates in the environment, moving from land or water to air and back again, often changing forms as it circulates. Mercury may be released to the environment by weathering of rocks and soil, forest fires or through volcanic activity. Anthropogenic releases may be from coal-fired power plants, waste incinerators, mining, cement production, industrial processes involving mercury, municipal wastewater and from healthcare facilities (Sang and Lourie 1997; Doiron et al. 1998; Environment Canada 1999). A recent inventory indicated that approximately one tonne of mercury is emitted to the environment annually from anthropogenic sources in Atlantic Canada (Doiron et. al., 1998). While the proportion that hospitals and health care facilities contribute to that total is relatively low, mercury releases may be locally significant. For example, one gram of mercury released per year is enough to contaminate all the fish in a lake with a surface area of 8 hectares (Environment Canada 2002).

Hospitals and other health care facilities use a variety of products that contain mercury, such as thermometers, blood pressure cuffs, fluorescent lamps, batteries, laboratory chemicals and many cleaning products (Pollution Probe 1996; US EPA 1999; Donovan 2000). The three primary pathways mercury is released into the environment from hospitals are: releases into the air by incinerators burning biomedical waste containing mercury; landfilling of mercury-containing solid waste; and releases into wastewater.

As significant users of products containing mercury, hospitals have the opportunity to play a key role in protecting public health and the environment by minimizing their use and release of mercury-containing products and waste. Some hospitals in Atlantic Canada have already conducted pollution prevention studies and/or implemented programmes that have included measures to reduce mercury released to the environment (ACAP Humber Arm undated; ACAP Cape Breton 2000). The status of those types of initiatives at other large hospitals in Nova Scotia was unknown.

In 2001, Environment Canada Atlantic Region and the Nova Scotia Department of Environment and Labour conducted a study on mercury use and release from 17 larger hospitals in Nova Scotia (hospitals with more than 80 beds). Environment Canada visited each facility on two occasions to collect composite samples of the final wastewater from those facilities and had samples analyzed for total mercury concentrations. In addition, a questionnaire was completed by the appropriate hospital staff at each facility, with the assistance from Nova Scotia Department of Environment and Labour (NSDEL) staff, to determine mercury use patterns at each facility. The information resulting from the study provides baseline information and may help identify future pollution prevention opportunities at the facilities studied.

2.0 Methods

2.1 Study Site Selection

Hospitals in Nova Scotia with more than 80 beds were identified from the Canadian Almanac and Directory 2001. The Facilities Manager or General Manager at each hospital was contacted by telephone and by letter to solicit their facility's cooperation in the study.

2.2 Mercury Use Pattern Assessment

A questionnaire was developed entitled "Mercury Use and Reduction Initiatives at Nova Scotia Hospitals" (Appendix A). The questionnaire had two sections; Section 1 dealt with mercury equipment and products, including clinical equipment, facility equipment, laboratory equipment and chemicals and cleaning products; Section 2 dealt with mercury policies and practices. Instructions were provided to have Section 1 of the questionnaire completed by the appropriate hospital staff member in each department of a facility and returned to NSDEL by fax. Section 2 was completed as an interview with the assistance of NSDEL staff. A number of mercury use pattern surveys were used as reference material to develop the questionnaire used in the study (Pollution Probe and Health Care Environment Network 1996; New Hampshire Hospital Association 1999; ACAP Cape Breton 2000; Donovan 2000). The questionnaires were mailed to each hospital and telephone calls were made to each facility to ensure questionnaires were completed.

2.3 Sample Collection

Wastewater samples were collected by Environment Canada staff on two occasions at each facility during the period between July 30th and December 11th, 2001. Hospital maintenance staff and municipal works staff were contacted to determine the appropriate manhole(s) to sample the final wastewater from each facility (Appendix B). In addition, in many cases, a manhole "upstream" of the facility was identified to collect a reference sample.

Twenty four hour composite wastewater samples were collected using Sigmamotor 900 Series automated samplers that were suspended inside manholes. The samplers were programmed to collect a specified volume of wastewater every 30 minutes. New Teflon tubing (3/8" ID) was used for intake tubing and new silicone header tubing was used in the sampler for each sample. A clean stainless steel and nylon weighted end piece was used to prevent clogging of the intake tubing at the bottom of each manhole. The sample was collected in a 15 L glass carboy that had been detergent rinsed and then subsequently rinsed with water, distilled water, high purity omni-trace nitric acid and finally with distilled water again. Ice packs were placed around the carboy during the collection period.

After the 24 hour collection period, the sample was thoroughly mixed in the glass carboy and samples were then poured off into sample bottles. One nitric acid washed 100 mL sovrirel glass bottle was filled for total mercury analysis and one 500 mL Teflon bottle that had been extensively washed with nitric acid was filled for ultra-trace mercury analyses. The Environment Canada sampling protocol for determining ultra-trace mercury concentrations was followed for all sampling activities (Brun and Leger 1996). Once collected, samples were stored in a cooler on ice and then immediately shipped to the Environment Canada laboratory in Moncton, NB for analyses.

For Quality Control purposes, three Trip Blank samples and two Equipment Blank samples were collected, over the course of the sampling programme, for total mercury and ultra-low mercury analyses.

At each sample location, whenever possible, a flow measurement was taken using a Global Flow Probe FP201, which was extendable to 5 m. At some locations flow measurements were not taken due to inadequate flow in the bottom of the manhole or too large a distance from street level to the wastewater stream at the bottom of the manhole (exceeded the length of the flow meter when fully extended).

2.4 Mercury Analyses by Cold Vapour Atomic Absorption Spectrometry (CVAAS)

At the laboratory, samples collected for total mercury analyses were preserved with 3 mL of 0.1 N potassium dichromate in order to avoid analyte degradation.

The principle of the CVAAS method (Agemian and DaSilva 1979) consists of oxidizing the organomercury compounds in the samples to inorganic mercury (Hg^{2+}) by sulphuric acid, dichromate and UV photooxidation. This automated system provides not only the advantage of speed and reliability, but also a closed system where the oxidation can take place without loss of volatile mercury compounds. After oxidation, the mercuric ions were reduced with stannous sulphate in hydroxylamine sulphate - sodium chloride solution to elemental mercury. The elemental mercury was sparged from solution with a stream of air passed through a cold vapour absorption cell. The mercury was determined at the 253.7 nm line by flameless atomic absorption spectrometry. The concentration of Hg was obtained by comparing instrument response to a sample with a calibration curve obtained from instrument responses to a set of standards. The detection limit for this method was 0.02 µg/L.

For Quality Control purposes, each run consisted of method blanks, standards, certified reference materials, spike and duplicate samples. A Certified Reference Material was used to monitor method efficiency and for method validation purposes (accuracy and precision). The CRM used for this project was a NIST Standard Reference Material 1641 "Mercury in Water" at concentrations of 0.056 µg/L (Low) and 0.453 µg/L (High). Analyte recoveries were in the range of 93% to 116% for the low concentration and 94% to 103% for the high concentration.

2.5 Ultra-trace Mercury Analyses by Cold Vapour Atomic Fluorescence Spectrometry (CVAFS)

At the laboratory, samples collected for ultra-trace mercury analyses were preserved with 3 mL of bromide chloride and stored at or near 4°C until analyses were performed. Only those samples where mercury was not detectable using the CVAAS technique were analyzed using the CVAFS method (US EPA 1998).

The principle of this method consists of bringing the mercury in the sample into solution by digesting the sample with bromine monochloride while exposed to UV lamps. Excess Br-Cl was neutralized with hydroxylamine and the mercury reduced to its neutral and volatile form with stannous chloride ($SnCl_2$). The mercury was purged out of the sample onto a gold coated sand trap or a gold wire trap and was subsequently desorbed and swept through the atomic fluorescence detector by heating the trap. The response obtained for the sample was compared to that obtained from a multi-component standard(s) (containing different levels of Hg concentrations). The detection limit for this method was 0.5 ng/L (0.0005 µg/L).

For Quality Control purposes, each run consists of method blanks, standards, certified reference materials, spike and duplicate samples. A Certified Reference Material was used to monitor method efficiency and for validation purposes such as accuracy and precision. The CRM used for this project is a NIST Standard Reference Material 1641 "Mercury in Water" at concentrations of 5.72 ng/L. Analyte recoveries were in the range of 75% to 125%.

3.0 Results

3.1 Mercury Use Pattern Assessment

Twelve hospitals provided data for Section 1 of the Use Pattern Assessment Survey, although only seven of the seventeen larger hospitals that had a wastewater assessment conducted as part of this study completed Section 1. The other five hospitals were smaller facilities (under 80 beds) that were part of a larger Health Board. Data summarized in this section is for the seven larger hospitals.

Table 1 provides a summary of mercury used in clinical, facility and laboratory equipment and products. All hospitals reported using limited quantities of mercury thermometers. Other equipment and products had varying levels of use. Items with no reports of use included: Weighted Cantor tubes; Weighted Miller-Abbot tubes; Nursing incubator thermostats; Displacement plunger relays; Flame sensor/safety valves; Hitachi Chem Analyzers; and electron microscopes.

Table 1:
Summary of Mercury (Hg) Use at Nova Scotia Hospitals* in Clinical, Facility and Laboratory Equipment and Products

Products/Equipment	Percentage of Hospitals Reporting Use	Range of # of Units in Stock or Use	Estimate of Total Hg at all Sites (g) **	Disposal Methods (# of hospitals reporting a specific method)
Mercury thermometers	100%	8 to 380	278	Recycled (1) Haz Waste (4) Incinerated (1) Other (1)
Sphygmo-Manometers	57%	3 to 80	10,640	Haz Waste (1) Other (2) Not reported (1)
Button batteries	14%	8	0.2	Haz Waste (1)
Feeding tubes	14%	40	1,900	Gen Waste (1)
Weighted esophageal dilators	57%	9 to 36	91,130	Haz Waste (1) Other (2) Unknown (1)
Dental amalgams	14%	Up to 1000 capsules	500	Haz Waste (1)
Mercury-containing lamps	43%	1 to 17,752	206	Haz Waste (2) Not reported (1)
Gauges with liquid mercury	14%	12	Unknown	Not reported (1)

Products/Equipment	Percentage of Hospitals Reporting Use	Range of # of Units in Stock or Use	Estimate of Total Hg at all Sites (g) **	Disposal Methods (# of hospitals reporting a specific method)
Equipment with mercury switches	43%	2 to 15	67	Haz Waste (1) Not reported (2)
Mercury barometers	29%	1	1,600	Haz Waste (2)

* Hospitals reporting information included: Cape Breton Regional Hospital; Colchester Regional Hospital; Dartmouth General Hospital; Highland View Regional Hospital; IWK-Grace Hospital; St. Martha's Hospital; Yarmouth Regional Hospital.

** The mercury content of products/equipment used to calculate the estimate of total mercury at all sites is presented in Appendix C.

Sphygmomanometers or blood pressure cuffs and weighted esophageal dilators were also used by a large percentage of hospitals. Those two items accounted for the majority of the total mercury by volume at all of the study sites, 96% of the estimated 106,320 g.

Disposal methods for various mercury-containing equipment and products varied widely between hospitals. At least two facilities were disposing mercury-containing items incorrectly, one by incineration and one in the general waste.

Table 2 presents a summary of mercury used in laboratory chemicals. Like mercury-containing equipment and products, laboratory chemical use varied between hospitals. Five chemicals/products accounted for approximately 98% of the estimated 753.5 g of total mercury used at all sites. Those products were: B5 Fixative; mercurochrome; Hg chloride; Zenker's solution; and Hg (II) oxide.

Table 2:
Summary of Mercury (Hg) Use at Nova Scotia Hospitals* in Laboratory Chemicals

Chemical/Product	Percentage of Hospitals Reporting Use	Range of Amounts Used in 2000	Estimate of Total Hg used at all sites (g)**
Histological fixatives	57%	60 to 41,000 L	0.5
Zenker's solution	29%	100 to 1,000 mL	79
Thimerosal	14%	1 mL	3.5
Carbol-fuchin stain	72%	50 to 1,500 mL	0.002
Gram iodine stain	86%	50 to 2,000 mL	0.003
Mercurochrome	29%	25 to 30 mL	194
Phenolic mercuric	14%	20 g	Unknown
Acetate	14%	100 g	Unknown
Alum	72%	200 to 2,500 g	0.004
Mercury nitrate	14%	50 g	0.05
Hematoxylin (Solution A)	72%	100 to 6,000 mL	Trace

Chemical/Product	Percentage of Hospitals Reporting Use	Range of Amounts Used in 2000	Estimate of Total Hg used at all sites (g)**
Cesium Internal Std.	14%	2,600 mL	Unknown
Mercury chloride	43%	25 to 50 g	85
Mercury (II) oxide	57%	10 to 25 g	62
Mercury (II) chloride	14%	10 g	7.4
B5 Fixative	43%	200 to 8,000 mL	322
Gomori's	57%	100 to 2,400 mL	Unknown

* Hospitals reporting information included: Cape Breton Regional Hospital; Colchester Regional Hospital; Dartmouth General Hospital; Highland View Regional Hospital; IWK-Grace Hospital; St. Martha's Hospital; Yarmouth Regional Hospital.

** The mercury content of chemicals/products used to calculate the estimate of total mercury used at all sites is presented in Appendix C.

Most hospitals reported using commercial hazardous waste companies for disposal of unused chemical/products or laboratory wastes. Some hospitals reported neutralizing fixatives and pouring them down the drain.

The cleaning products portion of the Use Pattern Assessment Survey generated very little data. Three of the seven hospitals reported no use of the 11 products identified as containing mercury. The other four hospitals reported use of very small quantities (< 2,000 mL) of four products.

Nine of the seventeen study hospitals provided information for Section 2 of the Mercury Use Pattern Assessment Survey, including six of the seven larger hospitals that provided information for Section 1 of the Survey. Table 3 presents a summary of the mercury policies and procedures in place at the study sites.

Table 3:
Mercury Policies and Practices at Nova Scotia Hospitals*

Policies or Practices	Percentage of Hospitals Reporting
Mercury purchasing policy developed and in use	44%
Program for identification and inventory of existing stocks of mercury-containing equipment and products in place	56%
Procedures for the proper disposal of elemental mercury and mercury-containing equipment	56%
Procedures for cleaning up mercury spills	67%

* Hospitals reporting information included: Aberdeen Hospital; Cape Breton Regional Hospital; Colchester Regional Hospital; Fisherman's Memorial Hospital; Highland View Regional Hospital; IWK-Grace Hospital; Queen Elizabeth II Hospital; St. Martha's Hospital; Yarmouth Regional Hospital.

All of the study hospitals reported that purchasing was done centrally for their district, rather than purchasing done by individual hospitals or units/departments within hospitals. Only four of the nine hospitals reported that a mercury purchasing policy was developed and in use for their facility.

Five of the nine hospitals, including all that had a mercury purchasing policy developed and implemented, reported that their facility had a program in place to identify and reduce mercury-containing products. Those programs had been in place from 2 to 12 years. Products identified for elimination ranged from thermometers, sphygmomanometers, mercury-containing batteries to everything that contained mercury in the hospital. Only three of the five hospitals with mercury identification and reduction programmes reported having completed a recent inventory of mercury-containing items; those inventories were conducted 1.5 to 4 years ago.

Five of the nine hospitals reported that their facility had procedures in place for the proper disposal of elemental mercury and mercury-containing equipment. Only two hospitals reported that they had procedures for cleaning and refilling instruments with mercury; most facilities either no longer do that or were not sure if that was still done.

Six of the nine hospitals had formal procedures or policies in place for cleaning up mercury spills.

3.2 Wastewater Assessment

Quality control samples collected during the sampling programme provided a level of assurance of the data collected in the environmental survey of mercury concentrations in hospital wastewater samples. Mercury concentrations in trip blanks collected during the sampling programme ranged from <0.0005 to 0.0013 µg/L. Those concentrations were well below any detections at reference sites or hospital sampling locations. Mercury concentrations in equipment blanks were also very low, ranging from 0.0009 to 0.004 µg/L.

Table 4 presents the mercury concentrations found in hospital wastewaters and reference site wastewaters. Total mercury concentrations in hospital wastewaters ranged from 0.0064 to 0.26 µg/L with a mean concentration of 0.10 µg/L. Total mercury concentrations in wastewaters from reference sites, not influenced by hospital discharges, ranged from 0.0086 to 0.07 µg/L with a mean concentration of 0.03 µg/L. Mean mercury concentrations from hospitals were 3.3 times higher than mean concentrations from reference sites.

Table 5 presents an estimate of annual mercury loadings from hospital discharges. Estimated annual mercury loadings ranged from 3.21 to 138.6 g/yr with an average discharge of 65.3 g/yr. There was considerable variation at some sites due to variations in wastewater flows as well as mercury concentrations in the wastewater. Using the most conservative estimate for each site, at a minimum an estimated 375 g of Hg are released in wastewater from the 17 hospitals surveyed annually.

Table 4:
Mercury (Hg) Concentrations in Wastewater Samples from Nova Scotia Hospitals and Reference Sites

Sample Location*	Sample Date	Hg Concentrations In Hospital Wastewater (µg/L)	Hg Concentrations in Wastewater From Closest Reference Site (µg/L)**
Aberdeen Hospital	15-Aug-01	0.18	0.07
New Glasgow	04-Dec-01	0.20	0.02
Cape Breton Regional Hospital	18-Oct-01	0.12	0.02
Sydney	07-Nov-01	0.09	0.02
Colchester Regional Hospital	09-Aug-01	0.16	0.0129
Truro	05-Dec-01	0.06	0.0086
Dartmouth General Hospital	01-Aug-01	0.11	0.03
Dartmouth	24-Oct-01	0.11	0.02
Glace Bay Regional Hospital	18-Oct-01	0.09	0.02
Glace Bay	07-Nov-01	0.11	0.02
Fisherman's Memorial Hospital	23-Aug-01	0.06	0.06
Lunenburg	14-Nov-01	0.07	0.06
Highland View Regional Hospital #1	12-Oct-01	0.05	0.04
Amherst	20-Nov-01	0.15	0.02
Highland View Regional Hospital #2	12-Oct-01	0.20	0.04
Amherst	20-Nov-01	0.26	0.02
IWK-Grace Hospital #1	04-Oct-01	0.0064	0.02
Halifax	11-Dec-01	0.02	0.02
IWK-Grace Hospital #2	04-Oct-01	0.09	0.02
Halifax	11-Dec-01	0.17	0.02
New Waterford Consolidated Hospital	18-Oct-01	0.10	0.02
New Waterford	07-Nov-01	0.10	0.02
Northside General Hospital	18-Oct-01	0.12	0.02
North Sydney	07-Nov-01	0.12	0.02
Queen Elizabeth II – Halifax Infirmary	26-Sept-01	0.02	0.02
Halifax	11-Dec-01	0.02	0.02
Queen Elizabeth II – Victoria General	01-Oct-01	0.08	0.02
Halifax	11-Dec-01	0.25	0.02
Soldier's Memorial Hospital	13-Sept-01	0.13	0.0173
Middleton	28-Nov-01	0.21	0.0173
South Shore Regional Hospital	23-Aug-01	0.04	0.0589
Bridgewater	14-Nov-01	0.04	0.02
St. Martha's Hospital	15-Aug-01	0.05	0.07
Antigonish	04-Dec-01	0.03	0.03
Valley Regional Hospital	13-Sept-01	0.08	0.0173
Kentville	28-Nov-01	0.04	0.0173
Yarmouth Regional Hospital	28-Aug-01	0.08	0.07
Yarmouth	30-Oct-01	0.15	0.07

*** Descriptions of sample locations are presented in Appendix B.**

**** Descriptions of sample locations for Reference Sites are presented in Appendix D.**

Table 5:
Estimated Annual Mercury (Hg) Loadings from Nova Scotia Hospitals

Sample Location*	Sample Date	Average Velocity (m/s)	Hg Concentrations in Hospital Wastewater (µg/L)	Estimated Annual Hg Loadings** (g/yr)
Aberdeen Hospital	04-Dec-01	0.467***	0.20	70.69
Cape Breton Regional	18-Oct-01	0.529	0.12	48.04
	07-Nov-01	0.296	0.09	20.16
Colchester Regional	09-Aug-01	0.614	0.16	74.35
	05-Dec-01	0.35	0.06	15.89
Dartmouth General	01-Aug-01	0.584	0.11	48.62
	24-Oct-01	0.775	0.11	64.52
Glace Bay Regional	18-Oct-01	0.244	0.09	16.62
	07-Nov-01	0.162	0.11	13.49
Fisherman's Memorial	14-Nov-01	0.112	0.07	5.93
Highland View Regional #1	12-Oct-01	0.111	0.05	4.20
	20-Nov-01	0.548	0.15	62.21
Highland View Regional #2	12-Oct-01	0.056	0.20	8.48
	20-Nov-01	0.387	0.26	76.16
IWK-Grace #1	11-Dec-01	0.567	0.02	8.58
IWK-Grace #2	11-Dec-01	0.283	0.17	36.41
New Waterford Consolidated	--	N/A	--	--
Northside General	07-Nov-01	0.425	0.12	38.60
Queen Elizabeth II – Halifax Infirmary	26-Sept-01	0.46	0.02	6.96
	11-Dec-01	0.212	0.02	3.21
Queen Elizabeth II – Victoria General	01-Oct-01	0.106	0.08	6.42
	11-Dec-01	0.298	0.25	56.39
Soldier's Memorial	13-Sept-01	0.177	0.13	17.42
	28-Nov-01	0.872	0.21	138.60
South Shore Regional	23-Aug-01	0.549	0.04	16.62
	14-Nov-01	1.255	0.04	37.99
St. Martha's Hospital	04-Dec-01	0.353	0.03	8.02
Valley Regional	28-Nov-01	0.546	0.04	16.53
Yarmouth Regional	28-Aug-01	0.616	0.08	37.30

***Descriptions of sample locations are presented in Appendix B.**

****Based on an estimated volume of wastewater - 8 cm deep, 30 cm wide.**

*****The average velocity could not be measured in the hospital waste steam. The figure used is for the upstream station.**

4.0 Discussion

The data obtained from the Mercury Use Pattern Assessment Survey showed that there were varying levels of awareness in the hospitals surveyed regarding products, equipment and chemicals that contain mercury. In addition, awareness of proper disposal procedures for mercury-containing items varied between hospitals, indicating a lack of knowledge of proper disposal methods at some facilities. Awareness of the need for procedures and policies for cleaning up mercury spills was also lacking at some facilities.

A number of facilities have tried to reduce or eliminate products and equipment which contains large amounts or mercury (e.g. blood pressure cuffs) through removal and proper disposal of the mercury at the end of the useful life of the item or proper disposal of the entire item. Preferential purchasing of non-mercury containing equipment was used where feasible. In some cases, newer and superior technologies have replaced the mercury in equipment (e.g. use of tungsten vs mercury weights in some equipment). That being said, large quantities of mercury are still in use at some NS hospitals in equipment and products such as weighted esophageal dilators, feeding tubes, sphygmomanometers and thermometers where non-mercury containing alternatives exist (US EPA 1999).

There appears to be a general lack of awareness regarding smaller sources of mercury such as lab chemicals, certain battery types and fluorescent lamps. A case in point, one large hospital in the survey indicated that it had been working for 12 years to reduce/eliminate mercury-containing products through proper disposal at end of life and preferential purchasing of non-mercury alternatives. Despite that successful programme, that facility indicated only lab chemicals with mercury in their name (e.g. mercury chloride, mercury oxide) were targeted for elimination where alternatives existed. However, if mercury was not in the chemical's name (e.g. B5 Fixative), the hospital was not aware of the mercury content of the chemical and would not have sought an alternative. Another example of the general lack of awareness of smaller sources of mercury, was the under reporting of mercury-containing lamps in the Survey. Only one hospital provided a realistic estimate of mercury-containing lamps (fluorescent lighting) at their facility, indicating that most hospitals might not be aware of the mercury content of these items and their disposal requirements.

Five lab chemicals accounted for approximately 98% of the estimated mercury use at all of the study sites. Non-mercury containing alternatives exist for many of these products, such as zinc formalin for histological fixatives such as B5 and Zenker's solution (US EPA 1999). The varied use of lab chemicals between hospitals infers that alternatives may exist for many of other lab products as well.

With respect to the adequacy of mercury management at the study hospitals, two hospitals reported having a comprehensive programme of mercury management with: a mercury purchasing policy; a programme implemented to identify and reduce mercury-containing products; a recent inventory of mercury-containing equipment and products; a procedure in place for disposal of elemental mercury; and a procedure implemented for clean-up of mercury spills. Two other facilities reported having four of those five above elements of a mercury management programme in place. Three hospitals had one or two elements in place and two facilities had none of those policies or procedures implemented.

Facilities which did not have existing programmes, policies or procedures for mercury source reduction and disposal identified a lack of information on which products and equipment contained mercury as a limitation to reducing or elimination mercury-containing items. Some facilities

indicated that the Survey was useful for raising awareness of which products and equipment contained mercury.

When asked to discuss barriers to the identification and elimination of mercury sources from hospitals, some facilities commented that information was needed to assist their facilities in the identification of mercury-containing products. In addition, examples of policies and practices from other hospitals dealing with mercury management including purchasing and spill clean-up were not thought to be readily available.

While some hospitals have already made efforts to reduce mercury use and implement environmentally responsible mercury management efforts, mercury concentrations in hospital wastewaters remain higher than background concentrations in most of the hospitals surveyed. Even for hospitals that have implemented significant mercury reduction measures such as the Cape Breton Regional Hospital, mercury concentrations in final wastewaters were three to four times higher than reference site concentrations. It has been postulated that trace amounts of mercury tend to collect in the organic material (sludge) that may be present in plumbing systems and, as a consequence, can slough off into the wastewater stream at any time (MWRA 2001). As no Nova Scotia hospitals, to our knowledge, have conducted industrial cleaning of their plumbing systems, that may be a significant source of mercury contamination of hospital wastewater streams, particularly where mercury reduction initiatives have already been implemented.

Service Nova Scotia and Municipal Relations (2001) has published a model sewer discharge by-law for Nova Scotia communities. In the Sewer Discharge By-Law 19, the maximum concentration of total mercury that may be discharged to sanitary or combined sewers is 100 µg/L. That value is three orders of magnitude higher than the total Hg concentrations found in hospital wastewaters in this study. The Halifax Regional Municipality has a Wastewater Discharge By-Law (By-Law W-101) that has more stringent requirements for total mercury discharges. In that by-law, discharges to wastewater facilities may not exceed 10 µg/L total mercury and discharges to stormwater systems may not exceed 1 µg/L (HRM 2001). Total mercury concentrations in hospital wastewaters were all well below these values as well.

Notwithstanding the fact that mercury concentrations in wastewaters from hospitals surveyed were all well below sewer discharge by-laws, impaired reproduction in sensitive aquatic organisms has been shown to occur at aqueous concentrations of mercury between 0.03 and 1.6 µg/L (Eisler 1987). Sixteen of the 17 hospitals surveyed had mercury concentrations within that range of concentrations. In addition, due to the persistent and bioaccumulative properties of mercury, local discharges may be environmentally relevant.

Estimated annual mercury loadings at NS hospitals varied widely between sites. Most of those estimated loadings were within the range of 14 to 620 g/yr of mercury discharged from European hospitals in Germany, Austria, Belgium, Italy and the Netherlands (Hubner et al. 2001).

In summary, while many hospitals in Nova Scotia have already made efforts to reduce mercury use and implement environmentally responsible mercury management practices, there appears to be a many pollution prevention opportunities to reduce mercury use at most hospitals in the province. Hospitals indicated a lack of information on identifying less obvious sources of mercury and on sample policies/practices for mercury handling and management as main barriers to implementing mercury reduction programmes. A lack of factual information was also cited as the most common barrier in implementing mercury reduction programmes at Ontario hospitals (Donovan 2000).

Agencies promoting pollution prevention should make available that type of information to provincial hospitals.

All hospitals in Nova Scotia, if they haven't already done so, should consider implementing the following recommendations in order to become a mercury-free facility:

- Assign a lead person to be accountable for environmental management activities in the hospital, including mercury reduction and management activities;
- Conduct and regularly update an inventory of mercury-containing equipment, products and chemicals and gradually replace them with less harmful, non-toxic alternatives;
- Develop a mercury phase-out policy and train and provide information to purchasing officers to allow the gradual phase out of mercury-containing equipment, products and chemicals;
- Review the disposal practices and spill clean-up procedures for mercury-containing equipment and products and make the necessary changes to those practices and procedures to ensure that mercury and mercury-containing products are properly disposed of.

Despite efforts to reduce mercury use at some hospitals, mercury concentrations in hospital wastewaters remain higher than background concentrations raising doubts about the effectiveness of those measures. A follow-up study should be conducted to: determine whether mercury-contaminated sludge in hospital plumbing systems is responsible for the contamination of hospital wastewaters; and identify "hot spots" within hospital operations to allow a further evaluation of pollution prevention opportunities in those facilities. In the meantime, hospitals should investigate whether, or how frequently, drain traps, sumps or pipes in plumbing systems are cleaned and how that waste is disposed.

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APPENDIX A

Mercury Use and Reduction Initiatives at Nova Scotia Hospitals

Introductory Information

This survey is part of a joint project between Environment Canada and the Nova Scotia Department of the Environment and Labour. The information requested will provide us with a better understanding of the amounts and effects of mercury use in your hospital. In addition, it will provide baseline information that could help identify future pollution prevention opportunities for your facility.

Section 1 (Mercury Equipment and Products) of this survey should be completed by the appropriate contact in each department of your facility by **July 30, 2001**. Once Section 1 is completed, the survey should be faxed to Ms. Lynda Rankin, Nova Scotia Department of the Environment and Labour, fax (902) 424-0503.

Section 2 (Mercury Policies and Practices) of this survey will be completed as an interview at your facility. Please identify a contact below who Ms. Rankin can contact to schedule an interview. The questions that will be asked in the interview are presented in Section 2 of the survey.

Contact Information: *Person to whom questions regarding entire facility's mercury policies and practices can be addressed*

Facility Name: _____ Department: _____

Contact Name: _____ Contact Title: _____

Contact Phone: _____ Contact Fax: _____

E-mail: _____

Questions?

Contact Les Rutherford, Environment Canada
Phone: (902) 426-2295
E-mail: les.rutherford@ec.gc.ca
or
Contact Lynda Rankin, NS Department of the Environment and Labour
Phone: (902) 424-2578
E-mail: rankinlx@gov.ns.ca

Mercury Use and Reduction Initiatives at Nova Scotia Hospitals

Section 1: Mercury Equipment and Products

Please have the appropriate person(s) in your facility complete all the parts of Section 1 of this survey. Once Section 1 is completed, the survey should be faxed to Ms. Lynda Rankin, Nova Scotia Department of the Environment and Labour at (902) 424-0503 by **July 30, 2001**.

Hospital Name: _____

1.1 Clinical Equipment:

Contact Name: _____ Contact Title: _____

Contact Phone: _____ Contact Fax: _____

Department: _____ E-Mail: _____

Please provide best estimates for the information requested below. Purchasing information should be provided for the year 2000. In the blank spaces please add any other items used at your facility that may contain mercury.

Products/Equipment	**# of units in stock**	**Item currently in use (Y/N)?**	**# of units purchased in 2000**	**Circle how item is disposed.** Haz = hazardous waste *Gen = general waste* *R = recycled* *W = discharged as wastewater* *B = bio-hazard waste* *O = other*
Mercury thermometers				*Haz Gen R W B O*
Sphygmomanometers (blood pressure cuffs)				*Haz Gen R W B O*
Button batteries (mercury oxide and mercury zinc) used in pacemakers, hearing aids, etc				*Haz Gen R W B O*
Weighted esophageal				*Haz Gen R W B O*
Weighted Cantor tubes				*Haz Gen R W B O*
Weighted Miller-Abbott				*Haz Gen R W B O*
Feeding tubes				*Haz Gen R W B O*
Nursing incubator thermostat				*Haz Gen R W B O*
Dental amalgams				*Haz Gen R W B O*

Comments: _____

_____

_____

_____

1.2 ***Facility Equipment*** *(includes non-patient care areas)*:

Contact Name: _____ Contact Title: _____

Contact Phone: _____ Contact Fax: _____

Department: _____ E-Mail: _____

Please provide best estimates for the information requested below. Purchasing information should be provided for the year 2000. In the blank spaces please add any other items used at your facility that may contain mercury.

Products/Equipment	**# of units in stock**	**Item currently in use (Y/N)?**	**# of units purchased in 2000**	**Circle how item is disposed.** Haz = hazardous waste Gen = general waste R = recycled W = discharged as wastewater B = bio-hazard waste O = other
Mercury thermometers				*Haz Gen R W B O*
Batteries (mercury oxide and mercury zinc) used in alarms, pumps, cardiac monitors, etc.				*Haz Gen R W B O*
Mercury-containing lamps (fluorescent, ultraviolet, HID)				*Haz Gen R W B O*
Thermostats with mercury switches (e.g., non – electronic thermostats)				*Haz Gen R W B O*
Gauges with liquid mercury				*Haz Gen R W B O*
Equipment with mercury switches (e.g., tilt or "silent" switches)				*Haz Gen R W B O*
Displacement/Plunger relay				*Haz Gen R W B O*
Vacuum system (may contain mercury using manometers)				*Haz Gen R W B O*
Flame sensor/safety valve (in gas-fired equipment)				*Haz Gen R W B O*
				Haz Gen R W B O

Products/Equipment	# of units in stock	Item currently in use (Y/N)?	# of units purchased in 2000	Circle how item is disposed. Haz = hazardous waste Gen = general waste R = recycled W = discharged as wastewater B = bio-hazard waste O = other
				Haz Gen R W B O
				Haz Gen R W B O
				Haz Gen R W B O

Comments: _____

_____

_____

_____

1.3 Laboratory Equipment and Chemicals:

Contact Name: _____ Contact Title: _____

Contact Phone: _____ Contact Fax: _____

Department: _____ E-Mail: _____

Please provide best estimates for the information requested below. Purchasing information should be provided for the year 2000. In the blank spaces please add any other items used at your facility that may contain mercury.

Products/Equipment	# of units in stock	Item currently in use (Y/N)?	# of units purchased in 2000	Circle how item is disposed. Haz = hazardous waste *Gen = general waste* *R = recycled* *W = discharged as wastewater* *B = bio-hazard waste* *O = other*
Mercury thermometers				*Haz Gen R W B O*
Batteries (mercury oxide and mercury zinc)				*Haz Gen R W B O*
Hitachi Chem Analyzer				*Haz Gen R W B O*
Electron microscope				*Haz Gen R W B O*
Mercury barometers				*Haz Gen R W B O*
				Haz Gen R W B O

Products/Equipment	# of units in stock	Item currently in use (Y/N)?	# of units purchased in 2000	Circle how item is disposed. Haz = hazardous waste *Gen = general waste* *R = recycled* *W = discharged as wastewater* *B = bio-hazard waste* *O = other*
				Haz Gen R W B O

Comments:_____

_____

_____

_____

Please estimate the facility's use of these chemicals in volume used per year (e.g. kg/yr, g/yr, mL/yr) for the year 2000. In the blank spaces please add any others chemicals used that may contain mercury

Chemical	In use? (Y/N)	Amount used in 2000 (volume/yr)	Chemical	In use? (Y/N)	Amount used in 2000 (volume/yr)
Histological fixatives			Hematoxylin (Solution A)		
Zenker's solution			Mucolexx		
Thimerosal			Ohlamacher		
Carbot-funchin stain			Cajal's		
Gram iodine stain			Calmco		
Mercurochrome			Cesium Internal Std.		
Immu-sol			Mecury chloride		
Carmoy-Lebrun			Mercury (II) oxide		
Shardin			Mercury (II) chloride		
Takata's reagent			Mercury iodide		
Golgi's			Mercury nitrate		
Phenolic mercuric			Channing's Solution		
Acetate			B_5 Fixative		
Alum			Helly		
Mercury nitrate			Gomori's		
Million's reagent			Stabilur tablets		
Shardin					
Nesser's solution					
Phenylmercuric acetate					

How does the lab dispose of used/waste or outdated chemicals/reagents?

_____

_____

_____

Comments: _____

_____

_____

_____

*1.4 **Cleaning Products** (for general housecleaning):*

Contact Name: _____ Contact Title: _____

Contact Phone: _____ Contact Fax: _____

Department: _____ E-Mail: _____

Please provide best estimates for the information requested below. Please estimate the facility's use of these cleaning products in volume used per year (e.g. kg/yr, g/yr, mL/yr) for the year 2000. In the blank spaces please add any others products used that may contain mercury.

Product	**In use? (Y/N)**	**Amount used in 2000 (volume/yr)**	**Product**	**In use? (Y/N)**	**Amount used in 2000 (volume/yr)**
Ajax powder			Lysol direct		
Alconox soap			Murphy's oil soap		
Borax pads			Soft Cide soap		
Comet cleaner			Soft scrub		
Derma soap					
Joy/Ivory/Sunlight Dishwashing soap					
Sparkleen detergent					

Comments: _____

_____

_____

_____

Mercury Use and Reduction Initiatives at Nova Scotia Hospitals

Section 2: Mercury Policies and Practices

These questions will be asked during a brief interview on-site with the appropriate personnel at your facility. The interview will take approximately 30 minutes.

Purchasing

1. Is purchasing done centrally for the whole facility or is each unit/department responsible for its own purchasing?

2. Does your facility have a policy (policies) regarding the purchase of mercury-containing products? (If yes, please elaborate.)

Identification of Mercury-containing Products

1. Does your facility have a program in place to identify and reduce mercury-containing supplies and equipment?

2. **If no,** do you feel you have enough information to identify the major mercury containing supplies and equipment used in this hospital?

3. **If yes,**

   How long has this program been operating?
   What types of mercury-containing items are you eliminating?
   When was the most recent inventory of mercury-containing items conducted in your facility?
   Did it cover all areas of your facility?

Have you encountered any barriers or difficulties while attempting to eliminate mercury-containing items from your facility? (If yes, please elaborate.)

Operational Procedures and Management of Mercury-containing Wastes

1. Is there a staff member devoted full/part time to waste management, environmental management or environment health and safety?

2. Does your facility have a procedure for:
   - cleaning and refilling instruments with mercury?
   - disposal of elemental mercury and mercury-containing equipment?
   - cleaning up mercury spills?

3. How are mercury-contaminated materials from a spill clean up disposed of?

4. Does your facility have a battery disposal program?

5. Are drain traps, sumps, and pipes in the sewer lines regularly cleaned? (If yes, how is the waste material disposed of?)

Can we help you/Can you help others

1. Is there any information you would like to receive from us regarding mercury handling/management or environmental management in general?

2. Is your facility willing to share its environmental policies and guidelines with other hospitals?

APPENDIX B

Sample Locations

Sample Name	Sample Location
Aberdeen Hospital, New Glasgow	Manhole at intersection of East River Rd. and Pine St.
Cape Breton Regional Hospital, Sydney	Manhole in front of parking lot at NW corner of hospital
Colchester Regional Hospital, Truro	Manhole on Willow St. south of Shell Station
Dartmouth General Hospital, Dartmouth	Manhole on hospital grounds before pumping station at the corner of Pleasant St. and Mount Hope
Glace Bay Regional Hospital, Glace Bay	Manhole at back of hospital next to loading dock
Fisherman's Memorial Hospital, Lunenburg	Manhole at intersection of High St. and Brook St.
Highland View Regional Hospital #1, Amherst	Manhole at Townshend Rd. entrance to hospital
Highland View Regional Hospital #2, Amherst	Manhole on hospital grounds at Charles St. entrance to hospital
IWK-Grace Hospital #1, Halifax	Manhole in front of Emergency Bay doors on South St.
IWK-Grace Hospital #2, Halifax	Manhole in parking lot east of old main entrance to the IWK on South St.
New Waterford Consolidated Hospital, New Waterford	Manhole next to front entrance of hospital
Northside General Hospital, North Sydney	Manhole NE of main entrance of hospital
Queen Elizabeth II – Halifax Infirmary, Halifax	Manhole south of Summer St. entrance of hospital
Queen Elizabeth II – Victoria General, Halifax	Manhole next to loading dock at corner of Tower Rd. and South St.
Soldier's Memorial Hospital, Middleton	Manhole behind hospital across from the Boiler House
South Shore Regional Hospital, Bridgewater	Manhole on hospital grounds between parking lot and the corner of Allan Dr. and Streatch Dr.
St. Martha's Hospital, Antigonish	Manhole in street (Rte. #337) across from J.M. Law office
Valley Regional Hospital, Kentville	Manhole on sidewalk north of main entrance of hospital
Yarmouth Regional Hospital, Yarmouth	Manhole on lawn east of loading dock behind the hospital.

APPENDIX C

Mercury (Hg) Content of Clinical, Facility, Laboratory Equipment and Chemicals

Products/Equipment/ Chemicals	**Hg Content**	**Source**
Mercury thermometers	0.5 g	US EPA (2002)
Sphygmomanometers	70 to 90 g	US EPA (2002)
Button batteries	~3.5 to 11 mg	www.epa.gov/glnpo/bnsdocs/hg/thermfaq.htlm
Feeding tubes	3.5 mL	St. Martha's Hospital
Weighted esophageal dilators	1.36 kg	New Hampshire Hospital Association
Dental amalgams	50% Hg by weight	http://jhhs.client.web-health.com/web-health/topics/GeneralHealth/generalhealthsub/generalhealth/dental&oral/amalgams_vs.html
Mercury-containing lamps	11.6 mg	www.epa.gov/glnpo/bnsdocs/hgsbook/pdf
Equipment with Hg switches	3.5 mg	abe.www.ecn.purdue.edu/~mercury/src/devicepage.htm
Mercury barometers	800 g	US EPA (2002)
Histological fixatives	0.012 mg/L	http://www.epa.gov/grtlakes/bnsdocs/hgsbook/chemical.pdf
Zenker's solution	72 g/L	http://www.epa.gov/grtlakes/bnsdocs/hgsbook/chemical.pdf
Thimerosal	26% Hg	http://www.epa.gov/grtlakes/bnsdocs/hgsbook/chemical.pdf
Carbol-fuchin stain	1 mg/L	www.netcaster.com/cgi-bin/mercury/view.pl
Gram iodine stain	0.001 mg/L	www.netcaster.com/cgi-bin/mercury/view.pl
Mercurochrome	26% Hg	Biological Stains, 1977
Alum	1 µg/g	www.nap.edu/books/030903381/html/9.html
B5 Fixative	37 g/L	http://www.epa.gov/grtlakes/bnsdocs/hgsbook/chemical.pdf

APPENDIX D

Mercury (Hg) concentrations in wastewater samples from Nova Scotia Reference Sites

Reference Site	Sample Date	Hg concentrations in wastewater (µg/L)
Amherst	12-Oct-01	0.04
	20-Nov-01	0.02
Antigonish	15-Aug-01	0.07
	04-Dec-01	0.02
Bridgewater	23-Aug-01	0.06
	14-Nov-01	0.02
Dartmouth	01-Aug-01	0.03
	24-Oct-01	0.02
Lunenburg	23-Aug-01	0.06
Middleton	28-Nov-01	0.0173
New Glasgow	15-Aug-01	0.07
	04-Dec-01	0.02
Sydney	07-Nov-01	0.02
Truro	09-Aug-01	0.0129
	05-Dec-01	0.0086
Yarmouth	30-Oct-01	0.07